THE VALUE OF PERFORMANCE.
NORTHROP GRUMMAN

CSBF Requirements & Recommendations for Balloon Gondola Design

Scientific Ballooning Technologies Workshop 2019

Justin Marsh, CSBF
Mechanical Engineering Mgr, NBOC

Design Philosophy

- Structural Integrity
  - Primarily to survive “termination event” *(i.e. momentary free-fall followed by parachute opening)*
    - Safety
    - Mission Assurance
  - Has been sufficient for landing – although not a requirement
- Mission Assurance
  - Important to prevent damage
  - Allows for less than ideal launch conditions
- Staging/Pickup
  - Must be able to fit inside existing high bays
  - Allows for hoist pickup and roll out to launch vehicle
- Recovery
  - Some existing recovery limitations – particularly Antarctica
  - Crucial to stay within limitations for critical components

Structural Requirements

- Requirements are Changing
  - OM-220-10-H will be superseded by WFF-820 Program Guidance document
    - ***DRAFT available upon request, TBD on final release date***
  - Structural requirements only – Handbook/Guidelines to be relocated
- Notable Changes

Design Limit Loads (DLL) G's		
Vertical	@ 45°	Horizontal
10	5	5

Design Factor of Safety	
Yield	Ultimate
N/A	1.0

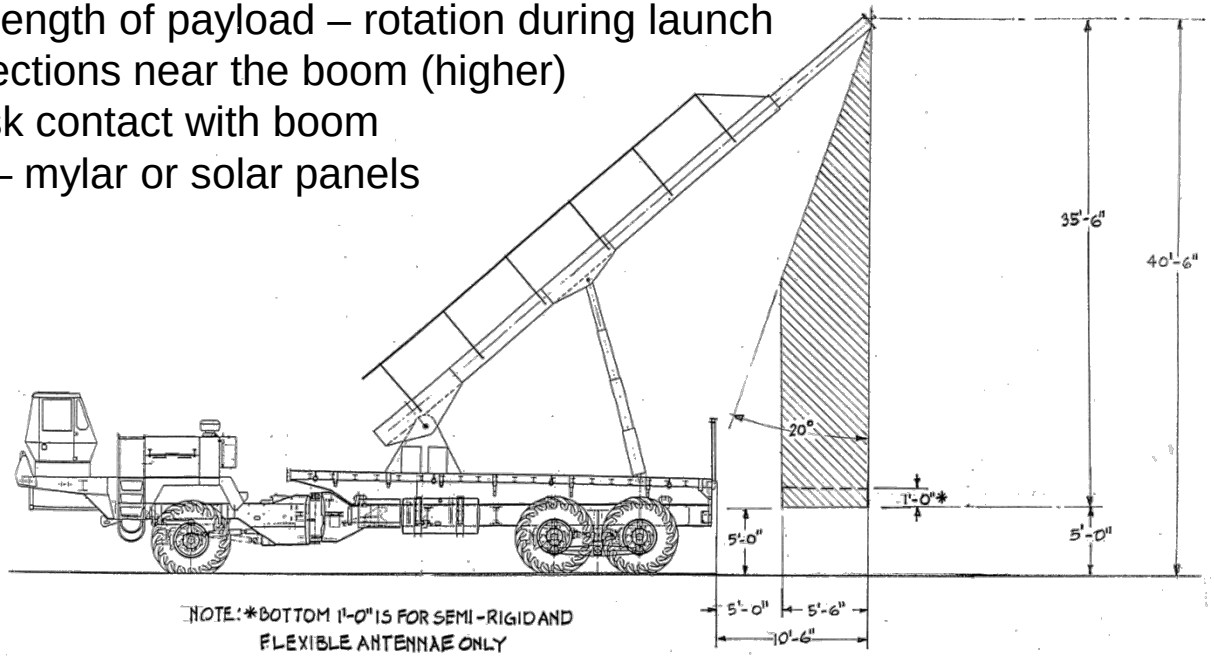
Design Limit Loads (DLL) G's		
Vertical	@ 45°	Horizontal
8	4	4

Design Factor of Safety	
Yield	Ultimate
1.25	1.4

  - Metallic materials with failure stress of **<u>5%</u>** *(previously 10% at -60°C)* strain or less, at worst case temperature limit shall be considered brittle.
  - Deliverables and Review Schedule better defined
- What isn't Changing?
  - Prescribed load cases for analysis
    - Inertial relief defined as preferred analysis method
  - Welded joints discouraged
    - Critical welds require proof testing
- Legacy Gondolas

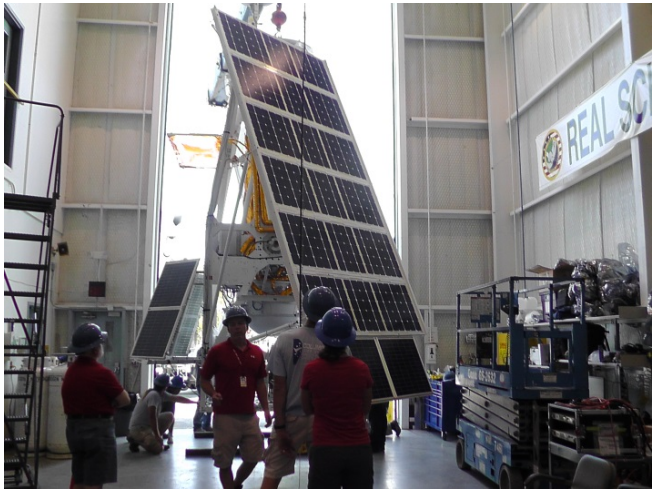
Mission Assurance

- Payload Must Be Able to Survive Launch
  - Dynamic Launch
    - Damage to antennae, solar panels, or other protruding objects
- Minimum Desired Distances From Launch Vehicle
  - "20 degree rule" – Assures minimum desired clearance from Launch Vehicle
  - 6 feet of ground clearance – avoids contact with ground (pendulum)
  - 5 feet of vehicle clearance – avoids contact with front of vehicle
- Other Observations
  - Width/Length of payload – rotation during launch
  - Wide sections near the boom (higher)
    - Risk contact with boom
  - "Sails" – mylar or solar panels



Staging & Gondola Pickup

- Facilities Limitations
  - Height & Width of Payload
    - Allow for weighing of payload inside high bay (Antarctica)
    - Allow for ease of roll in/and out of building



- Carts/Wheels/Stands
  - Allows operations to work underneath gondola
  - Ideally allows for ballast hoppers and solar panels to stay attached for rollout
    - Enormous time saver
  - Must be big enough for easy rollout
  - Must allow rotation of payload for vehicle pickup

Recovery

- Gondola Disassembly
  - Focus on ease/speed of disassembly
    - Allows for quicker recovery (Antarctica)
  - Accessibility of data vaults and other critical components
    - Trade-off between access and protection

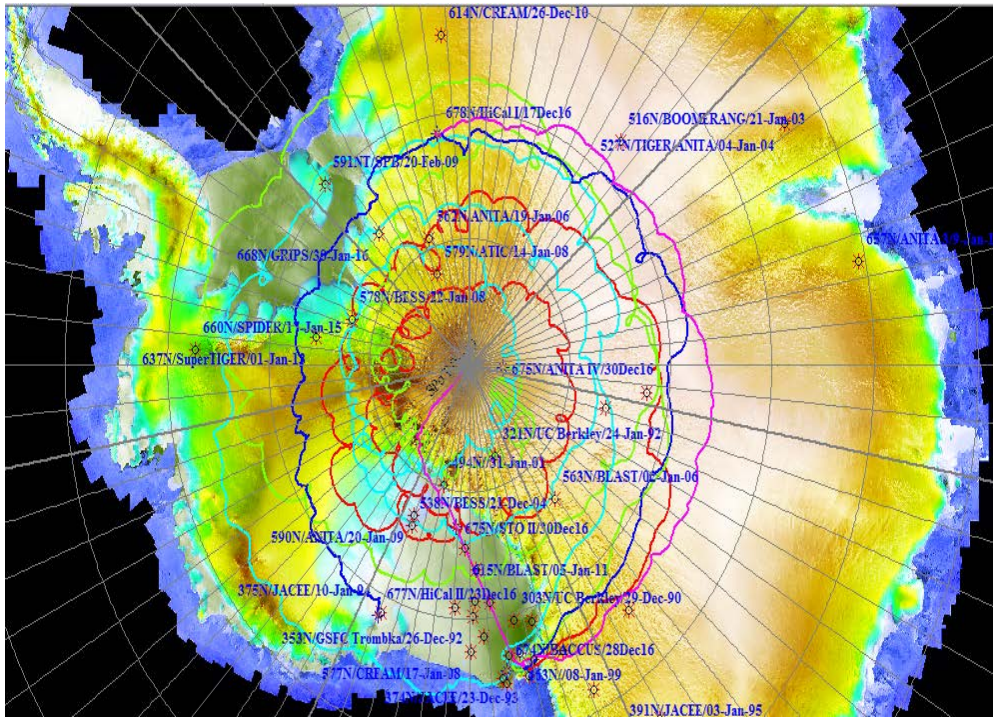
- Transport
  - Critical components to stay within a certain allowable size and weight
  - Limited by recovery vehicle
    - Helo
    - Twin Otter & Bassler (Antarctica)
    - Land Vehicles

Common Pitfalls and Recommendations

- Early Interface with CSBF
  - Aim to follow deliverables/review schedule
  - Pointing systems & critical hardware
    - Source traceable w/ certs
  - Placement of CSBF equipment
    - Thermal considerations
    - Antennae
    - Launch Straps
    - Ballast Hoppers
  - Gondola dimensions
    - “20 degree rule”
- Structural Analysis Margin
  - Final weights are usually higher than predicted!!
- Protective Cage for SIP
- Non-appropriate casters/tires
  - Hard to maneuver

Summary

- Stay in Touch
  - Justin Marsh
    - 903-723-8053
    - Justin.l.marsh@nasa.gov
    - Mechanical Engr Manager
  - Garret Wilbanks
    - 903-723-8020
    - Garret.s.Wilbanks@nasa.gov
    - Mechanical Engr
  - Hugo Franco
    - 903-723-8091
    - Hugo.franco@nasa.gov
    - Operations Manager



- Follow the Link
  - Structural Requirements: https://www.csbf.nasa.gov/documents/gondola/OM-220-10-H-A%20Structural%20Rqrmnts%20Gondola%20Design.pdf
  - LDB Support: https://www.csbf.nasa.gov/documents/ldb/LDB%20Support%20for%20Science%20EL-100-10-H%20rev%20A.pdf
  - Other Useful Documents: https://www.csbf.nasa.gov/docs.html

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN